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ABSTRACT

This paper presents implementation details related to the freshman integrated curriculum at Texas A&M University. Specifically, the need for strong integration between physics, calculus, engineering problem solving, engineering design graphics, and English is emphasized. The paper presents a brief summary of the design and pilot implementation phases done under the Foundation Coalition Program. The paper also provides a description of the institutionalization and scale-up phases, which lead to the current freshman integrated curriculum at the College of Engineering. The need for active learning, teaming, and technology-enabled education as part of an integrated curriculum is also emphasized. These three pedagogical models improved the effectiveness of the integrated curriculum at the College of Engineering by providing environments conducive to integration. Assessment and evaluation results collected during the pilot phases under the Foundation Coalition are presented. (Author/CCM)

The Freshman Integrated Curriculum at Texas A&M University

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Abstract *- In this paper we will present implementation details related to the freshman integrated curriculum at Texas A&M University. Specifically, we will motivate the need to strong integration between physics, calculus, engineering problem solving, engineering design graphics, and English. First we will present a brief summary of the design and pilot implementation phases done under the Foundation Coalition Program. We will then provide a description of the institutionalization and scale-up phases, which lead to the current freshman integrated curriculum at the College of Engineering. We will also motivate the need for active learning, teaming, and technology-enabled education as part of an integrated curriculum. We believe these three pedagogical models improved the effectiveness of our integrated curriculum by providing environments conducive to integration. We will present assessment and evaluation results collected during the pilot phases under the Foundation Coalition.*

The Foundation Coalition

The *Foundation Coalition for Engineering Education* represents a national collaborative effort involving several institutions focusing on the creation of an enduring ***foundation*** for student development and life long-learning. The *Foundation Coalition* has four major thrusts for educational transformation:

- To integrate course material across disciplines in order to motivate engineering problem solving and design;
- To develop the student's ability to work as a productive member of a "technical" team;
- that of and active/collaborative learning experience; and
- To use technology in the classroom in order to provide the students with enhanced design and problem solving tools.

The vision of the NSF Foundation Coalition is an engineering education partnership that will produce graduates who have an:

- Increased appreciation and motivation for life-long learning,
- Increased ability to participate in effective teams,
- Effective oral, written, graphical, and visual communication skills,
- Improved ability to appropriately apply the fundamentals of mathematics and the sciences,
- Increased capability to integrate knowledge from different disciplines to define problems, develop and evaluate alternative solutions, and specify appropriate solutions, and
- Increased flexibility and competence in using modern technology effectively for analysis, design, and communication.

The Foundation Coalition Program at Texas A&M University has developed integrated programs for the freshman and sophomore years and has facilitated significant improvements in many upper division courses and bridge programs [6]. This paper presents our development in the freshman integrated curriculum.

Evolution of the Freshman Integrated Curriculum

The College of Engineering had a common curricula for all engineering programs in the first year. At the beginning of the Foundation Coalition some departments were not satisfied with this curricula. This concern has been heightened by the declining

financial support of the instruction of ENGR 109 (a problem solving and programming course) from the College level, and perception of the actual content of courses, both engineering and non-engineering courses. The required curriculum at the beginning of the FC is shown in Figure 1. Some of the specific concerns with the curriculum were: ENGL 104 (freshman rhetoric and composition course) did not provided enough seats for all entering first year students; most engineering students were required to take CHEM 101 (first semester chemistry but not a prerequisite for second semester) before CHEM 102; some engineering faculty members were not certain of the value of ENGR 109; several engineering programs were inquiring about the need for ENDG 105 (a design graphics course); only 50-60% of incoming first year students placed into MATH 151 (first semester of engineering calculus), while 35-40% place in a lower course; some concerns about student retention of information from PHYS 218 (mechanics).

Foundation Coalition (FC) Curriculum

The First-Year of the FC curriculum was offered for the second time in the 1995-1996 academic year. The curriculum changed since the first offering so that two semester of physics (electricity and magnetism was brought to the first year) were included in the first year, and a new chemistry course was included in the curriculum. Concerns about the FC curriculum included: the reduction of PHYS 218 and PHYS 208 material from two four-hour courses to two three-hour courses; ability of incoming first-year students to handle this load of sciences, mathematics, and engineering courses; opportunities for students who did not place in MATH 151 and, consequently were not eligible for the curriculum; and the Chemical Engineering faculty was not satisfied with the new chemistry course.

Dwight Look College of Engineering
Freshman Year*

First Semester	(Th-Pr)	Cr	Second Semester	(Th-Pr)	Cr
ENGL 104 Comp & Rhetoric	(3-0)	3	CHEM 102 Fundamentals of Chemistry II	(3-0)	3
ENGR 109 Engineering Prob. Solving & Computing	(2-3)	3	CHEM 112 Chemistry Lab II	(0-3)	1
MATH 151 Engr. Mathematics I[1]	(3-2)	4	ENDG 105 Engineering Graphics	(0-6)	2
Directed electives[2]		6	MATH 152 Engineering Mathematics II	(3-2)	4
			PHYS 218 Mechanics	(3-3)	4
			Directed elective[2]		3
Military, air, naval science[3], or KINE 199	(0-2)	1	Military, air, naval science[3], or KINE 199	(0-2)	1
		17			18

*A grade of "C" or better will be required for the (CBK) Common Body of Knowledge Courses (MATH 151,152; PHYS 218; CHEM 102,112; ENGL 104; ENGR 109; and ENDG 105) and any courses designed by the individual engineering departments. Prerequisites for the CBK courses will not be included in the calculations. See description of individual majors and written requirements from the departmental offices.

1. Entering students will be given a placement test in mathematics. Test results will be used in selecting the appropriate starting course which may be at a higher or lower level.
2. Total requirements in this area are dependent on the individual majors. See the departmental major curriculum for course requirements.
3. State law permits the substitution of three hours of history and three hours of political science for a student in the program of an approved senior ROTC unit.

Figure 1. *The 1995-1996 Texas A&M University Undergraduate Catalog's College of Engineering's Freshman Curriculum*

Nonetheless, all engineering majors allowed students to opt to take the FC curriculum. However, if students did not complete the entire year in the FC curriculum there were some difficulties placing them in appropriate courses to finish the year and lose as least hours as possible.

The new chemistry for engineering course was adopted as the course required in the first year curriculum; however, Chemical Engineering was not satisfied with this being the only required first-year chemistry course. They were allowed to make a footnote on the next years catalog to require their majors to take a higher chemistry course in the first year.

Foundation Coalition
Freshman Year*

First Semester	(Th-Pr)	Cr	Second Semester	(Th-Pr)	Cr
ENGL 489 Comp & Rhetoric I	(2-0)	2	CHEM 489 Chemistry for Engineers	(3-3)	4
ENGR 489 Engineering Fund. I	(1-5)	3	ENGR 489 Engineering Fund. II	(1-4)	2
MATH 151 Engr. Mathematics I[1]	(3-2)	4	MATH 152 Engineering Mathematics II	(3-2)	4
PHYS 489 Mechanics	(2-2)	3	PHYS 489 Electricity & Optics	(2-2)	3
Directed electives[2]		3	ENGL 489 Comp. & Tech Writing	(2-0)	2
Military, air, naval science[3], or KINE 199	(0-2)	1	Military, air, naval science[3], or KINE 199	(0-2)	1
		16			16

*A grade of "C" or better will be required for the (CBK) Common Body of Knowledge Courses (MATH 489s; PHYS 489s; CHEM 489; ENGL 489; ENGR 489s) and any courses designed by the individual engineering departments. Prerequisites for the CBK courses will not be included in the calculations. See description of individual majors and written requirements from the departmental offices.

1. Entering students will be given a placement test in mathematics. Test results will be used in selecting the appropriate starting course which may be at a higher or lower level.
2. Total requirements in this area are dependent on the individual majors. See the departmental major curriculum for course requirements.
3. State law permits the substitution of three hours of history and three hours of political science for a student in the program of an approved senior ROTC unit.

Figure 2. The 1995-1996 Texas A&M University Foundation Coalition College of Engineering's Freshman Curriculum

Number and Recruitment of Students

The College of Engineering had 1987 students enrolled in first year courses, of which 1408 were incoming first year students and 338 were transfer students from other institutions. The remaining were students from General Studies who may become engineering majors, or students repeating courses. The number of students per course is shown in Table 1.

The FC targeted 200 students for enrollment in the FC curriculum, and actually enrolled 198 students. These students were enrolled in 2 sections. The incoming first-year students all attend one of several Summer conferences to register for fall courses. At these conferences the College of

Engineering allocated time to address all students about the FC curriculum. In addition, the WEST (Women in Engineering Science and Technology) and MEP (Multi-ethnic Engineering Program) programs each had sessions which addressed the option to enroll in the FC curriculum. After each conference the enrollment in the FC curriculum was assessed to monitor the distribution of students by department, minority status, and gender. Efforts were made toward the end of the summer to raise the enrollment of women and minority students. All academic departments allowed there incoming first year students to opt for the FC curriculum.

TABLE 1 Students in First Year Engineering Courses in 1995-1996 Academic Year*

	ENGR 109	ENDG 105	Pre-Calculus 150	Calculus I 151	Calculus II 152	Chemistry 102	Physics 218
FALL	1025	1017	758	1360	789	118	824
SPRING.	685	789	143	813	1082	686	660

*This table does not reflect 198 students enrolled in FC courses

The faculty participating in the FC curriculum included four engineering (1 Aerospace, 1 Civil, 2 Engineering Design Graphics), two mathematics, two physics, one chemistry, and four English faculty members. Of these thirteen, five had participated in the first year FC curriculum the previous year. Each of the new faculty members were identified by the faculty involved in the FC and consulted for their interest in participating in the FC courses. The faculty approached Department Heads to gain approval for participation in the FC. While none of these faculty had difficulty gaining approval for teaching in these courses, the College of Engineering Dean's Office was approached by almost all of these Departments to discuss the plans for the FC. These departments did not want the program to continue to grow until more discussion was conducted on the effectiveness and costs of the program.

A classroom was renovated for teaming and technology facilitation. This was a tiered classroom with long curved tables. Teams of 4 students include students from two adjacent tiers. The classroom was wired to handle a laptop computer for each student, however one laptop was provided for every two students. The room had computer projection, lighting modifications, and whiteboard modifications to better facilitate FC pedagogy. The room was utilized from 8:00-5:00 Monday through Friday with minor breaks by the FC first-year courses, and in the evenings were open for team and independent FC student activities.

One of the most important aspects in dealing with the effective implementation of the new curriculum is handling of administrative details [4,5,7]. Several of the most important administrative details dealt with in the early phases of the implementation of the FC were:

- gaining approval for teaching FC courses, the College of Engineering Dean's Office was approached by almost all of the Departments providing faculty to discuss the plans for the FC. (All of the departments were visited by the Associate or Assistant Deans and FC leaders to discuss concerns. In addition faculty meetings were attended by FC leaders in the Aerospace, Agricultural, Chemical, Civil, Computer, Electrical, Industrial, and Mechanical engineering programs.)
- The engineering, science, mathematics, and English departments did not want the program to continue to grow until more discussion was conducted on the effectiveness and costs of the program. (Data was provided on student outcomes and some data was provided on costs)
- The costs of supplies and time demands on technical support for the FC computers were under-estimated.
- The laptops were significantly harder to maintain compared to desk top computers.
- The undergraduate advisors were not comfortable on what to advise students to take if they left the FC after one semester, and what to do about being 2 hours short in physics hours, due to the FC physics courses. (FC leaders kept the advisors informed about students who were leaving the FC, and Physics described an existing course which would allow students to make up the two hours)
- Block enrollment of the students in FC courses was time demanding for staff. (Alternatives were discussed with the Registrars Office, however an acceptable alternative was not found)
- Chemical engineering was not satisfied with the new chemistry course for engineers. (The FC leaders and faculty attended a faculty meeting with Chemical Engineering to discuss the course content of the Chemistry course and its perceived deficiencies).

Development of the Pre-calculus Program

The College of Engineering adopted the FC developed Chemistry course, and the Mathematics department modified the syllabi of FC mathematics courses to be the syllabi of all of the MATH 151 and 152 courses. The adaptations in the mathematics courses changed the ordering of material, and in some cases it has moved some material from one course to another. The FC curriculum was the same as the curriculum in Figure 2, except CHEM 489 received a permanent course number of CHEM 107. The FC worked to develop a curriculum for students who were not calculus ready. This curriculum is shown in Figure 4.

Dwight Look College of Engineering
Freshman Year*

First Semester	(Th-Pr)	Cr	Second Semester	(Th-Pr)	Cr
ENGL 104 Comp & Rhetoric	(3-0)	3	CHEM 107 Chemistry for Engineering[1]	(3-3)	4
ENGR 109 Engineering Prob. Solving & Computing	(2-3)	3	ENDG 105 Engineering Graphics	(0-6)	2
MATH 151 Engr. Mathematics I[2]	(3-2)	4	MATH 152 Engineering Mathematics II	(3-2)	4
Directed electives[3]		6	PHYS 218 Mechanics	(3-3)	4
Military, air, naval science[4], or KINE 199	(0-2)	1	Directed elective[3]		3
			Military, air, naval science[4], or KINE 199	(0-2)	1
		17			18

*A grade of "C" or better will be required for the (CBK) Common Body of Knowledge Courses (MATH 151,152; PHYS 218; CHEM 102,112; ENGL 104; ENGR 109; and ENDG 105) and any courses designed by the individual engineering departments. Prerequisites for the CBK courses will not be included in the calculations. See description of individual majors and written requirements from the departmental offices.

1. CHEN requires 8 hours of freshman chemistry, which may be satisfied by CHEM 101/111 or CHEM 107 and CHEM 102/112. CBK grade point computation will include these 8 hours.
2. Entering students will be given a placement test in mathematics. Test results will be used in selecting the appropriate starting course which may be at a higher or lower level.
3. Total requirements in this area are dependent on the individual majors. See the departmental major curriculum for course requirements.
4. State law permits the substitution of three hours of history and three hours of political science for a student in the program of an approved senior ROTC unit.

Figure 3. *The 1996-1997 Texas A&M University Undergraduate Catalog's College of Engineering's Freshman Curriculum*

There were 2042 students enrolled in first-year curricula engineering courses. Of these, 1464 were first year students incoming students, and 314 were transfer students. The remaining students were either in General Studies and hope to enter engineering in the future, or were repeating courses. Table 3 shows the numbers of students enrolling in freshman engineering courses.

The FC targeted to enroll 200 students in the calculus ready program, and 196 students were enrolled. We also targeted 150 students to be enrolled in the pre-calculus program and 55 were enrolled. These students were solicited during the dean's conference during the summer pre-registration conferences, and by the departmental undergraduate advisors.

Foundation Coalition
Pre-Calculus Freshman Year*

First Semester	(Th-Pr)	Cr	Second Semester	(Th-Pr)	Cr
ENGR 189[1] Freshman Engineering			ENGL 104[1] Comp & Rhetoric	(3-0)	3

Orientation	(1-0)	1	CHEM 107[1] Chemistry for Engineers	(3-3)	4
MATH 150 Pre-Calculus	(3-2)	4	ENGR 489[1] Engineering Fund. I	(1-5)	3
Directed electives[2]		9	MATH 151[1] Engineering Mathematics I	(3-2)	4
Military, air, naval science[3], or			Military, air, naval science[3], or		
KINE 199	(0-2)	1	KINE 199	(0-2)	1
		15			15

Third Semester	**(Th-Pr)**	**Cr**
ENGR 489[1] Engineering Fund. II	(1-5)	3
PHYS 218[1] Mechanics	(3-3)	4
MATH 152[1] Engineering Mathematics II	(3-2)	4
Directed electives[2]		3
Military, air, naval science[3], or		
KINE 199	(0-2)	1
		15

*A grade of "C" or better will be required for the (CBK) Common Body of Knowledge Courses (MATH 489s; PHYS 489s; CHEM 489; ENGL 489; ENGR 489s) and any courses designed by the individual engineering departments. Prerequisites for the CBK courses will not be included in the calculations. See description of individual majors and written requirements from the departmental offices.

1. Special sections for FC Pre-Calculus students
2. Total requirements in this area are dependent on the individual majors. See the departmental major curriculum for course requirements.
3. State law permits the substitution of three hours of history and three hours of political science for a student in the program of an approved senior ROTC unit.

Figure 4. The 1996-1997 Texas A&M University Foundation Coalition College of Engineering's Pre-Calculus Freshman Curriculum

TABLE 3 Students in First Year Engineering Courses in 1996-1997 Academic Year*

	ENGR 109	ENDG 105	Pre-Calculus 150	Calculus I 151	Calculus II 152	Chemistry 107	Physics 218
FALL	1093	879	694	1408	671	196	771
SPRING	598	843	122	823	1070	768	678

*This table does not reflect 196 students enrolled in FC courses

Analysis shows that the minority and women enrollment went down significantly and only three factors may have caused this: 1) the MEP and WEST programs did not actively promote the FC curriculum during the summer conferences, or 2) feedback from previous year students, or 3) undergraduate advisors promoted the traditional program. In addition the shortfall in number of students enrolling in the pre-calculus program was analyzed and the lack of a significant number of courses, by name, in the engineering curriculum occurring in the first semester seemed to be the main deterrent.)

More faculty members were recruited to deliver the pre-calculus program. Mainly, engineering added a chemical engineering faculty and another engineering design faculty. The large FC classroom (seating up to 108 students) was completely utilized by the calculus ready program. Approval and funding for modifications to 2 more classrooms which were to seat up to 104 students were obtained. The pre-calculus students utilized various classroom which often serve ENGR 109 and ENDG 105 classes. These rooms had computer technology, but were not as conducive to teaming activities. Nevertheless, effective teamwork and collaborative learning was conducted in these more "traditional" classroom settings.

The key administrative concerns dealt with during this phase of the program were:

- facilities for teaming and technology enabled instruction were too scarce, even including the 2 new large rooms we could not handle the current first and second year loads
- faculty recruitment and training if the program is adopted across the programs was vital
- curricula was becoming required (College formed a first year curricula team with representatives from all engineering departments, math, physics, chemistry.)

Evolution of the Pre-calculus Program

The catalog description of the required first-year curriculum did not change for the College of Engineering. The calculus ready FC curriculum did not change, except for a new lab developed for the integration of physics, chemistry, and engineering.

The Pre-calculus ready FC curriculum changed as shown in Figure 5.

The target was for 200 students to enroll in the calculus ready curriculum, and for 150 to enroll in the pre-calculus ready curriculum. The program started with 156 students in the calculus ready curriculum and 85 students in the pre-calculus program. At the beginning of the academic year the final decision for full adoption of the freshman integrated curriculum was made by all academic department after the College committee on the first-year curriculum made its recommendations in the Spring of 1997. This created some problems in dealing with the recruitment of students for the FC pilots since most academic department wanted to wait and see how the final integrated curriculum would be implemented for all freshman engineers.

At the present the calculus ready program is in its final semester and the pre-calculus program is in the second semester while plans are in development for full implementation in the fall of 1998.

Course Delivery

All courses in the freshman integrated curriculum were delivered using active/collaborative leaning. All faculty member attended several training sessions offered by local and national experts in the field. All students participating in the program attended a four-hour team training session offered by a team of faculty. The local FC program also offered training for faculty in effective use of technology, teaming, and assessment and evaluation.

Institutionalization Plans

In the fall 1998 the College of Engineering at Texas A&M University will offer Foundation Coalition programs for all incoming freshmen. Most of the incoming students will be placed into cohorts similar to the ones piloted by the Foundation Coalition. These cohorts will vary in the number and type of courses integrated but will have the elements of active/collaborative learning, teaming, effective use of technology, and continuous improvement through assessment and evaluation.

New Plans for the Foundation Coalition

Plans for the freshman integrated program at Texas A&M University for the next 5 years will be focused on the following five objectives:

- Inclusive Learning Communities – The formation of learning communities to include industry interaction and co-curricular activities within the cohorts.
- Responsive Curricula – The development of formal mechanisms for responding to the needs and requirements of industry, faculty, students, and other stakeholders.
- Assessment and Evaluation – The continuous improvement of the curricula using new assessment and evaluation methodologies and the development of faculty-owned procedures for assessment and evaluation.
- Sharing – Effective dissemination of processes and results with other academic institutions and the development of affiliate members, national and international, of the Foundation Coalition.
- Institutionalization and Change Management – The development of models for effective management of curricular changes responding to academic cultures.

Measurement of Outcomes

One of the four principal thrust areas of the Coalition has been continuous assessment and evaluation of methods and outcomes. Criterion 3 of the ABET, Accreditation Board for Engineering and

Foundation Coalition
Pre-Calculus Freshman Year*

First Semester	(Th-Pr)	Cr	Second Semester	(Th-Pr)	Cr
ENGR 189[1] Freshman Engineering Orientation	(1-0)	1	PHYS 489 Mechanics	(3-3)	4
MATH 150 Pre-Calculus	(3-2)	4	ENGR 489[1] Engineering Fund. I	(1-5)	3
ENGL 104[1] Comp & Rhetoric	(3-0)	3	MATH 151[1] Engineering Mathematics I	(3-2)	4
CHEM 107[1] Chemistry for Engineers	(3-3)	4			
Directed elective[2]		3	Directed elective[2]		3
Military, air, naval science[3], or KINE 199	(0-2)	1	Military, air, naval science[3], or KINE 199	(0-2)	1
		16			15

Third Semester	(Th-Pr)	Cr
ENGR 489[1] Engineering Fund. II	(1-5)	3

MATH 152[1] Engineering Mathematics II	(3-2)	4
Directed electives[2]		6
Military, air, naval science[3], or		
KINE 199	(0-2)	1
		14

*A grade of "C" or better will be required for the (CBK) Common Body of Knowledge Courses (MATH 489s; PHYS 489s; CHEM 489; ENGL 489; ENGR 489s) and any courses designed by the individual engineering departments. Prerequisites for the CBK courses will not be included in the calculations. See description of individual majors and written requirements from the departmental offices.

1. Special sections for FC Pre-Calculus students
2. Total requirements in this area are dependent on the individual majors. See the departmental major curriculum for course requirements.
3. State law permits the substitution of three hours of history and three hours of political science for a student in the program of an approved senior ROTC unit.

***Figure 5**. The 1997-1998 Texas A&M University Foundation Coalition College of Engineering's Pre-Calculus Freshman Curriculum*

Technology, Criteria 2000 focuses on program outcomes and assessments that demonstrate graduate performance in 11 areas. The Coalition assessment program directly assesses seven of the 11 areas: a) an ability to apply knowledge of mathematics, science, and engineering; c) an ability to design a system, component, or process to meet desired needs; d) an ability to function on multi-disciplinary teams; e) ability to identify, formulate, and solve engineering problems; g) ability to communicate effectively; i) a recognition of the need for and an ability to engage in lifelong learning; and k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. It is anticipated that the Coalition assessment will serve as the basis for the College's overall ABET plan, adding components of assessment that were not a focus of the Coalition at Texas A&M, measured outcomes over the past two years indicate that:

(1) Coalition students performed better than their cohort group in critical thinking skills, calculus, and physics;

(2) Coalition students have a better GPA at the end of the freshmen year;

(3) Coalition retention rates for women and minorities is significantly better than for women and minorities not in the Coalition curriculum;

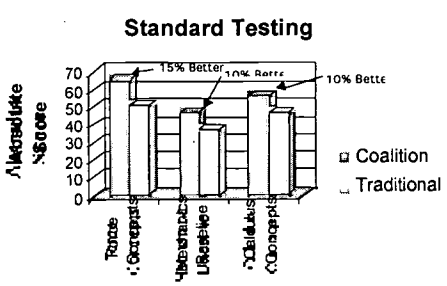
(4) Coalition students develop significantly better computer skills than their cohorts, particularly as relates to the use of the computer as a tool for problem solving; and

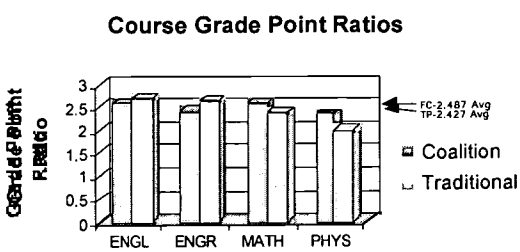
(5) Coalition students demonstrate a much greater facility to work in teams than the cohort group.

Some of the outcome data [1,3] is shown graphically in figure 6.

Summary

In this paper we presented the evolution of the freshman integrated curriculum at Texas A&M University. We also presented important implementation details based on our observation of the change process in our university. Results and future plans for our freshman program will also presented to reinforce the idea of effective systemic and systematic curricular reform being implemented at Texas A&M University.





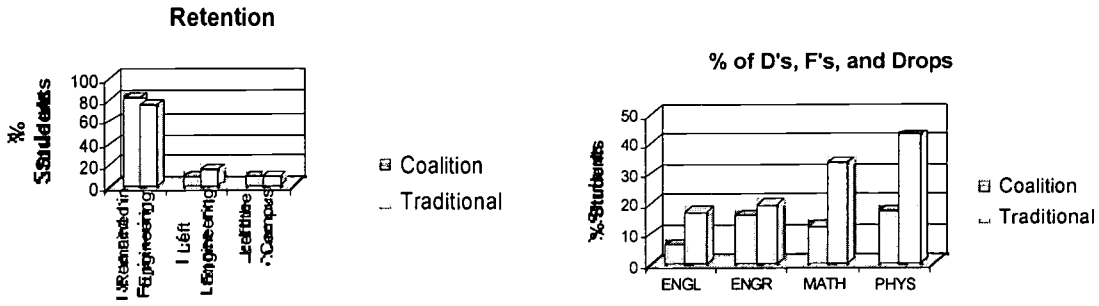


Figure 6: *Assessment Results for Freshmen Foundation Coalition*

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